

BBR WT Bar System

Hold-down solution for wind towers

High fatigue and
corrosion resistant





A Global Network of Experts

www.bbrnetwork.com

The BBR Network is recognized as the leading group of specialized engineering contractors in the field of post-tensioning, stay cable and related construction engineering. The innovation and technical excellence, brought together in 1944 by its three Swiss founders — Antonio Brandestini, Max Birkenmaier and Mirko Robin Ros — continues, more than 70 years later, in that same ethos and enterprising style.

From its Technical Headquarters and Business Development Centre in Switzerland, the BBR Network reaches out around the globe and has at its disposal some of the most talented engineers and technicians, as well as the very latest internationally approved technology.

THE GLOBAL BBR NETWORK

Within the Global BBR Network, established traditions and strong local roots are combined with the latest thinking and leading edge technology. BBR grants each local BBR Network Member access to the latest technical knowledge and resources — and facilitates the exchange of information on a broad scale and within international partnering alliances. Such global alliances and co-operations create local competitive advantages in dealing with, for example, efficient tendering, availability of specialists and specialized equipment or transfer of technical know-how.

ACTIVITIES OF THE NETWORK

All BBR Network Members are well-respected within their local business communities and have built strong connections in their respective regions. They are all structured differently to suit the local market and offer a variety of construction services, in addition to the traditional core business of post-tensioning.

BBR TECHNOLOGIES & BRANDS

BBR technologies have been applied to a vast array of different structures — such as bridges, buildings, cryogenic LNG tanks, dams, marine structures, nuclear power stations, retaining walls, tanks, silos, towers, tunnels, wastewater treatment plants, water reservoirs and wind farms. The BBR™ brands and trademarks — CONA®, BBRV®, HiAm®, HiEx, DINA®, SWIF®, BBR E-Trace and CONNÆCT® — are recognized worldwide.

The BBR Network has a track record of excellence and innovative approaches — with thousands of structures built using BBR technologies. While BBR's history goes back over 70 years, the BBR Network is focused on constructing the future — with professionalism, innovation and the very latest technology.

BBR VT International Ltd is the Technical Headquarters and Business Development Centre of the BBR Network located in Switzerland. The shareholders of BBR VT International Ltd are BBR Holding Ltd (Switzerland), a subsidiary of the Tectus Group (Switzerland) and KB Spennetknikk AS (Norway), a subsidiary of the KB Group (Norway).

High fatigue & corrosion resistant

As the wind power industry reaches for ever greater efficiency with taller towers and longer blades, the BBR R&D team has developed a wind tower bar with exceptional fatigue resistance and multi-layer corrosion protection — the BBR WT Bar System.

The BBR WT Bar System consists of high fatigue performance BBR C Bar with cold-rolled ISO-specified metric thread and multi-layer corrosion protection.

Using the BBR Network's long experience of working with load bearing construction systems — and indeed of providing post-tensioning for wind towers — the BBR WT Bar System has been specifically designed as a hold-down solution for wind tower foundations.

Although the design life of wind towers is generally up to 25 years, the design life expectancy of the BBR WT Bar System goes beyond that, thanks to the multi-layer corrosion protection system developed in line with state-of-the-art requirements.

While designing the BBR WT Bar System, fatigue performance has been tested and a value of 10 million load cycles has been achieved. This is unique in the market and is assurance of high durability and exceptional fatigue resistance.

The BBR approach to construction technology is to create durable — and thus sustainable — solutions for the future. Long design life and performance testing are two key elements of this strategy.

In the following pages, you will be able to learn more about the BBR WT Bar System features, installation, testing and quality assurance. This technology is available to the market, like many others the BBR Network currently delivers, as a response to feedback received — and with the highest level of quality and the BBR commitment to customer service.

2 System features & components

3 Corrosion protection

4 Production technology & quality assurance

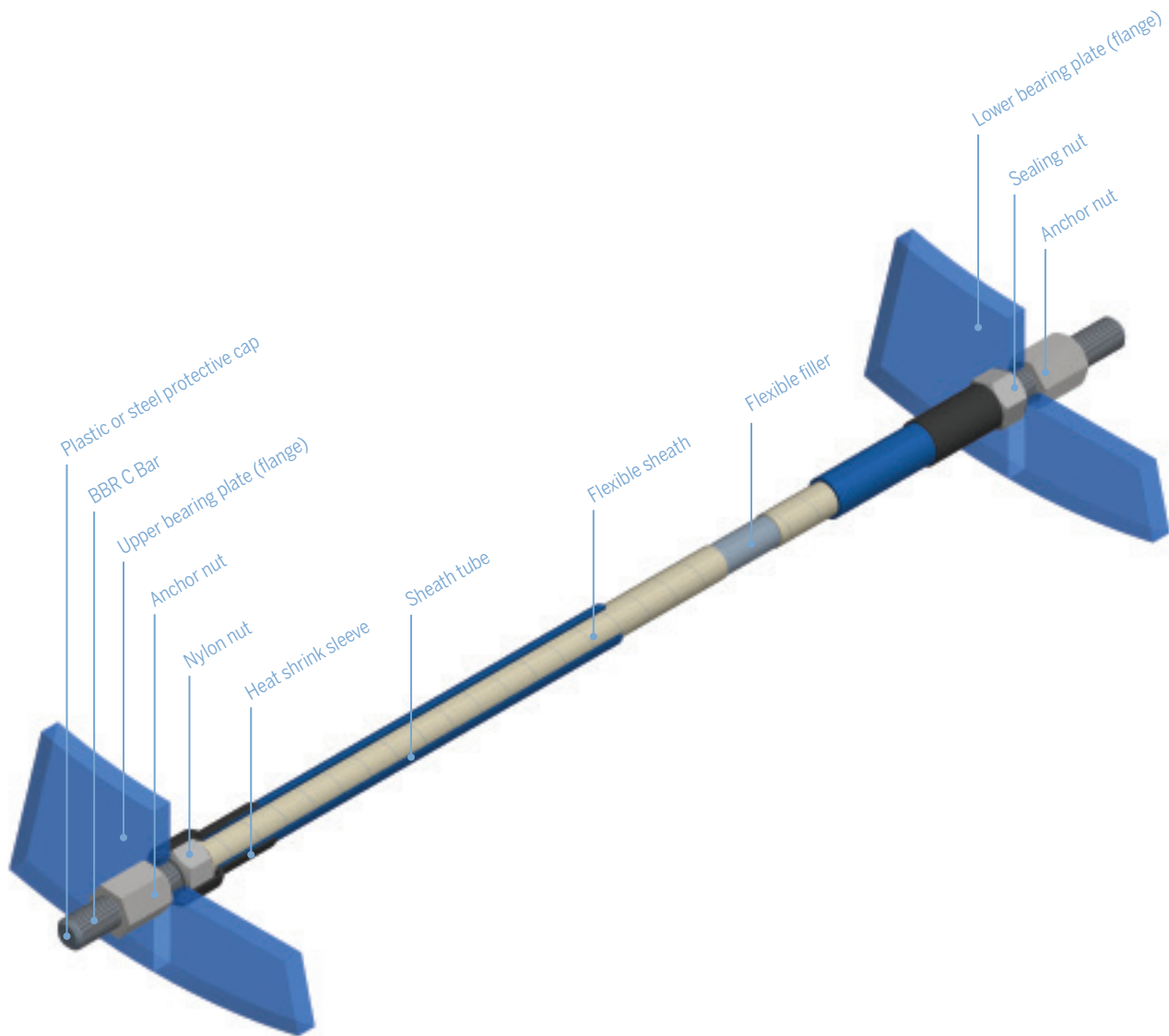
5 Installation & best practice

6 Testing & quality assurance to international standards

8 Quality, strength & durability

System features & components

The BBR WT Bar System represents a further stage in the strategic development of the BBR Bar Family which aims to provide the widest range of bar solutions which can be used across the broadest variety of construction and underground applications. The development of the BBR WT Bar System is a direct response to the growing wind tower industry and demand for high quality and reliable hold-down solutions.



Key benefits of the BBR WT Bar System

- High tensile alloy steel with increased resistance to corrosion.
- Cold-rolled and heat treatment process for fine structure crystallization and high load bearing capacity.
- Customized thread rolling and section lengths according to project requirements.
- Multi-layer corrosion protection according to European requirements .
- Tested and proven high fatigue performance to over 10 million load cycles at 80MPa stress range.

Despite there being no universal standard accepted and applied across the regions, BBR follows EU standards for high tensile prestressing steels and European Assessment Document EAD 160004-00-0301 (previously ETAG013) for the mechanical testing and evaluation of the BBR WT Bar System, as well as the corrosion protection philosophy applied to load bearing elements designed to be installed in aggressive conditions. As a result, the BBR WT Bar System achieved a high fatigue performance during testing to over 10 million load cycles at 80MPa stress range and is equipped with multi-layer corrosion protection system, a durable and redundant solution.

The BBR R&D engineers have, as you might expect, delivered additional value in terms of the design at the interface of the bar and wind tower flange, which ensures continuity of the corrosion protection at this stage and thus proper performance.

The BBR WT Bar System is a customized product available in project-specific lengths for the bar section and threaded part, supported by the BBR Network's well-known supply chain set-up which ensures quick lead times and first class quality assurance and control procedures.

BBR C8.8 Bar

D Nom	Weight	Cross Section	Yield force	Ultimate force
mm	kg/m	mm ²	kN	kN
M36	6.83	817	539	678
M39	8.12	976	644	810
M42	9.34	1120	739	929
M48	12.28	1470	970	1220

BBR C9.8 Bar

D Nom	Weight	Cross Section	Yield force	Ultimate force
mm	kg/m	mm ²	kN	kN
M36	6.83	817	588	735
M39	8.12	976	702	878
M42	9.34	1120	806	1008
M48	12.28	1470	1058	1323

BBR C10.9 Bar

D Nom	Weight	Cross Section	Yield force	Ultimate force
mm	kg/m	mm ²	kN	kN
M36	6.83	817	768	849
M39	8.12	976	917	1015
M42	9.34	1120	1052	1164
M48	12.28	1470	1381	1528

BBR C12.9 Bar

D Nom	Weight	Cross Section	Yield force	Ultimate force
mm	kg/m	mm ²	kN	kN
M36	6.83	817	898	996
M39	8.12	976	1073	1190
M42	9.34	1120	1232	1366
M48	12.28	1470	1617	1793

Corrosion protection

The BBR WT Bar System is fully protected against aggressive environments by a multi-layer protection solution to ensure its performance during its service life.

The BBR WT Bar System corrosion protection solution has the following features:

- The BBR C Bar is made of a high alloy steel which offers a high resistance against corrosion.
- The bar body between anchorages is fully covered by a flexible sheath and filler.
- As an additional layer of protection, a sheath tube is fitted over the bar body, covering the flexible sheath and filler and protecting them through the whole service life.
- The end of the sheath tube is sealed by a sealing ring or nylon nut. A heat-shrinkable sleeve is applied to the joint section to ensure it is completely watertight.
- After concrete casting, the main part of the bar body is embedded in the concrete foundation.
- A protection cap is installed to cover the end of the BBR C Bar and anchor nut. This also allows restressing, as well as regular inspection during the service life of the BBR WT Bar System.

The performance against corrosion of the BBR WT Bar System has been assured by a neutral salt spray test according to ISO 9227. The system has withstood 1,000 hours of testing without any sign of corrosion on the surface of the bar.



Production technology & quality assurance

One of BBR's long-held principles is not to compromise on the quality of the delivered product. Unlike other systems on the market where solutions might be adjusted to the local demand, BBR offers only full-strength BBR solutions. This is what the BBR brand stands for and what has come to be a sustainable approach over the past 75 years.

Uniquely in the industry, BBR has introduced Extended Triple Stage Quality Assurance procedures to ensure that only the highest quality deliveries are made to customers.

Stage 1: Factory Production Control (FPC) and continuous surveillance

BBR has implemented and continuously maintains a factory production control system ensuring that the final components are in full conformity with BBR system specifications and the applicable European and international standards. Within the framework of this factory production control, BBR, in coordination with the factory, carries out tests and controls in accordance with the prescribed test plan and commonly accepted European procedures.

Stage 2: Pre-Delivery Inspection (PDI)

The second stage of the BBR Quality Assurance process, taking inspiration from the automotive industry, is the performing of a Pre-Delivery Inspection. The PDI is carried out by BBR quality engineers just after the completion of any new production lot. PDI consists of a quality check list that includes visual inspection, geometrical control, material verification and quality documentation.

Stage 3: Sample testing (SaT)

Out of each batch, samples of the system components are randomly selected and tested in accordance with the prescribed test plan. Results of these sample tests are then assessed against the minimum performance of the system in relation to the associated required characteristics.

SECURITY FROM RELIABLE BRAND



Leading brand



Accountable partner



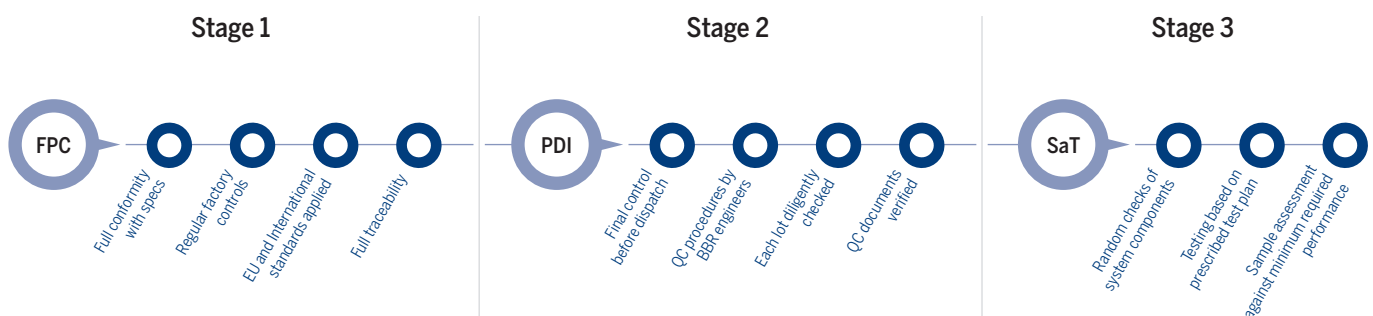
Full traceability across the entire production and supply chain



Global redundancy of BBR manufacturing plants



Solid and unique 3-stage quality assurance system



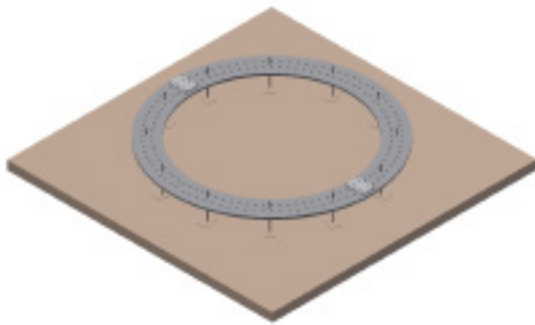
BBR Extended Triple Stage Quality Control procedure

Installation & best practice

Installation of the BBR WT Bar System is carried out by BBR Network Members who ensure that latest best practice is applied for every project. To protect the BBR WT Bar System during its working life, a multi-layer corrosion protection has been developed.

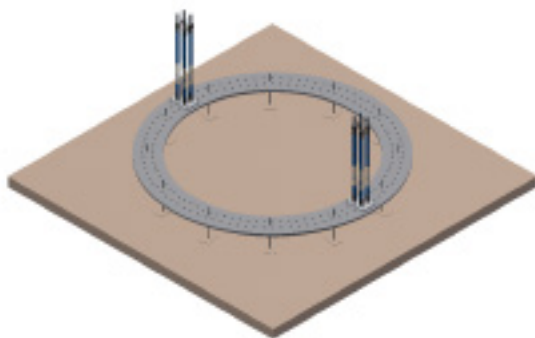
Installation

Installation of the BBR WT Bar System for wind turbine generator foundations is highly dependent on the individual project specification. For example, a typical installation process might have the stages shown in the adjacent diagrams.



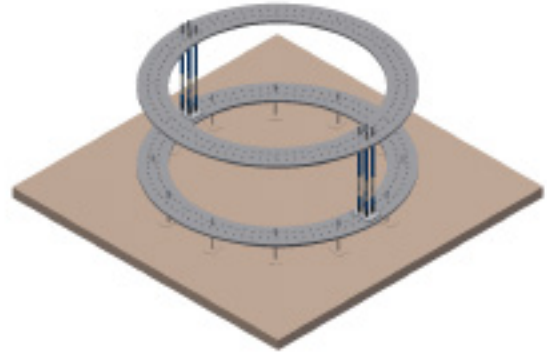
1. Lower flange leveling

- The lower anchor plate is moved into position and connected by adjustable screws to pre-installed steel plates embedded in the underside of the concrete foundation.
- The lower anchor plate is then leveled by the adjustable screws to the designated position.



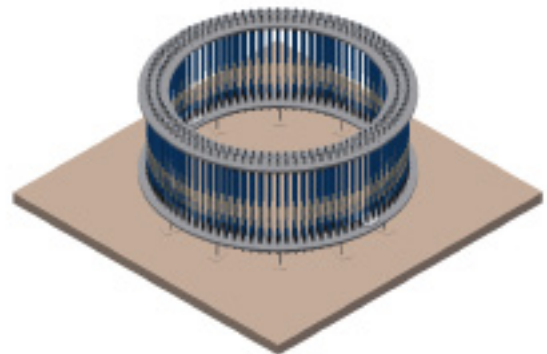
2. Installation of starter bars

- The prestressing adjustments bar kits (starters) for the connector plate are installed vertically on the lower anchor plate.



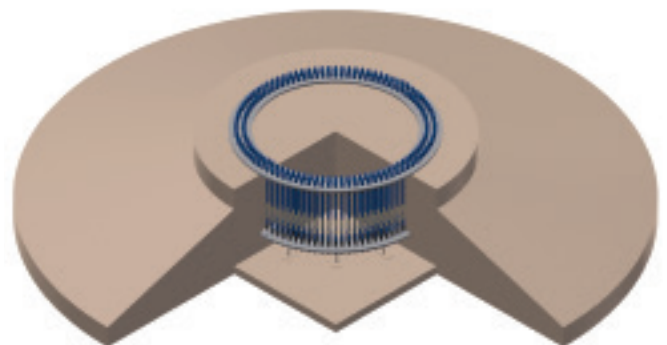
3. Installation of prestressing bar kits and upper anchor plates

- The upper anchor plate is held by a crane in the designed position.
- The upper anchor plate is then placed on the bar kits and anchor nuts on top of the upper anchor plate are installed.
- Adjustment of upper plate level, using starters and nylon anchor nuts, to achieve desired position.



4. Installation of the final prestressing BBR C Bars & completion

- The concentricity, elevation and flatness of the anchor plates are adjusted and verified.
- Installation of final BBR WT Bars
- Casting of foundation block, stressing procedure and post-grouting are performed according to project specification.



Testing & quality assurance to international standards

At BBR, we take pride in every piece of construction technology that we supply and this is why we conduct thorough independently verified laboratory testing. We require that each product conforms to the highest applicable standards and reaches our customers in prime condition, ready for immediate use.

Independently verified testing

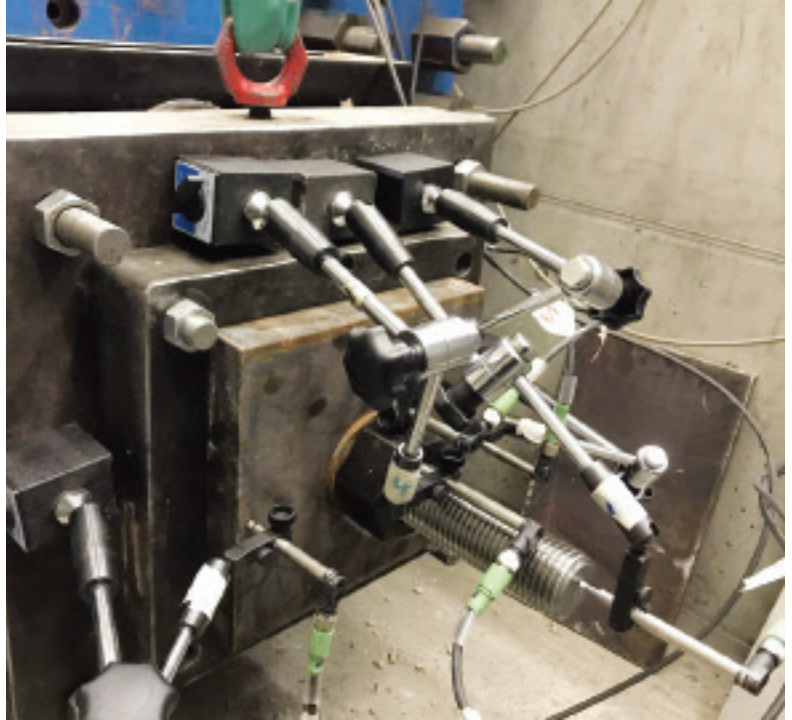
As a part of our testing program for technical approval, we have performed key tests to verify the major mechanical properties of the BBR WT Bar System.

We have carried out demanding mechanical and material tests on the system comprising bar and anchoring accessory components. All the tests were executed in independent accredited laboratories. The testing results proved that the BBR WT Bar System not only complies with the relevant European norms, standards and guidelines, but also fulfills additional requirements specified by some authorities.

Static test on tensile bar element

A bar specimen is stressed by standard stressing equipment to the maximum force (corresponding to ultimate tensile strength) at a specified loading rate. Elongation at the maximal force (A_{gt}) of the bar is measured during the tests.

The maximum force and force at yield must meet the specified values as 5% fractiles. A_{gt} is expected to be at least 3.5%.





Static test on bar system

To verify the resistance of the BBR WT Bar System against static load, a complete bar system kit — consisting of a BBR C Bar, bearing plates and anchor nuts — is assembled according to the envisaged final application.

The assembled system is stressed in equal stages up to 80% of the ultimate characteristic force using standard stressing equipment. Subsequently the load on the bar system kit is maintained for one hour (bonded application) or two hours (unbonded application) and immediately after, gradually stressed until complete failure. The measured maximum load should not be less than 95% of the actual ultimate strength and the failure of the bar system kit should not be induced by the failure of the anchorage nut or couplers. A_{gt} of the system is expected to be at least 2.0%. During the test, the elongation of the system during loading is continuously measured as well as any relative movement between the anchor nut and the bearing plate.

Fatigue test on bar system with subsequent static tensile test

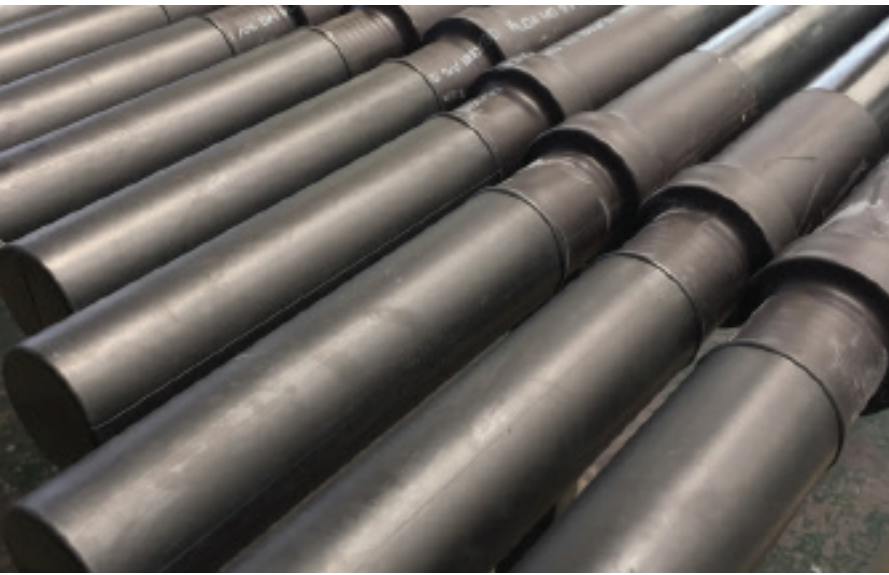
To verify the resistance of the BBR WT Bar system against fatigue, a complete bar system kit — consisting of a BBR C Bar, bearing plates and anchor nuts — is assembled according to the envisaged final application and stressed up to 65% of the nominated ultimate characteristic force. Subsequently the bar system kit is subjected to a fatigue test with two million load cycles at an upper load of 65% of the nominated ultimate characteristic force and an axial stress of 80MPa. At the end of the fatigue test there should not be any failure due to fatigue at the free length nor at the anchor nuts. After the fatigue test, the specimen is loaded up to failure. The load at failure must be at least 92% of the nominated ultimate characteristic force. During the test, the elongation of the system during initial loading is measured as well as any correlation with the number of cycles of the relative movement between the anchor nut and the bearing plate.

Extended fatigue test on bar system

As an additional test, in excess of specified requirements, the BBR WT Bar System was subjected to 10 million cycles, after which the system was loaded to failure. The BBR WT Bar System not only successfully withstood the fatigue impact of 10 million cycles, but also retained its functionality — the system nut was working and it was possible to unthread it from the bar. Failure load exceeded 92% of AUTS, thus complying with the other European requirements as well.

Additional testing on request

BBR has a long experience of working with international standards and laboratory test regimes, thus our engineers are able to perform any project-specific tests that may be required. For example, static and fatigue testing conforming with EN ISO 15630-1 and also with EAD 160004-00-0301 (previously ETAG013) are available. Please contact us for further details.



Quality, strength & durability

The BBR brand stands for uncompromising quality, strength and durability — and so very much more. From our Swiss roots, we have developed a wide range of construction technologies which are applied for all types of project across the globe.



Over the past seven decades, the BBR team has introduced some of the most advanced products and technology to the international market place. Our commitment to excellence in construction technology and techniques has never wavered — in fact, the BBR R&D team is continuously working on the development of products to support the construction industry worldwide.

Today, the BBR Network has many regular customers who have come to rely on us for:

- Robust and flexible solutions based on experience.
- Independently tested and certified technology.
- Stringent European Factory Production Control.
- Full traceability through BBR's unique E-Trace platform.
- Quality control inspections by BBR engineers.
- Installation by a well-trained, talented network of construction professionals.

The BBR quality promise extends to on site installation — BBR technology can only be applied to a project by fully trained and certified members of the BBR Network. Give your local BBR Network member a call about your next project — and let them help you shape a solution for your customer!



**The BBR Network —
international expertise &
technology delivered locally**



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